SYNOPSIS

'Synthesis and Study of Structural, Electrical and Magnetic Properties of Doped Mg-Mn Nanoferrites'

Submitted By: Somnath

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Introduction:

Recently, there is a renewed interest to know that what will happens to the properties of a material when the size of the material is reduced to the nano scale? Nanoscience and nanotechnology primarily deal with the synthesis, characterization, exploration, and exploitation of nanostructured materials. These materials are characterized by at least one dimension in the nanometer range. Nanostructures constitute a bridge between molecules and infinite bulk systems. Individual nanostructures include clusters, quantum dots, nanocrystals, nanowires, and nanotubes, while collections of nanostructures involve arrays, assemblies, and superlattices of the individual nanostructures. The physical and chemical properties of nanomaterials can differ significantly from those of the bulk materials of the same composition. Suitable control of the properties and response of nanostructures can lead to new devices and technologies.

The landmark lecture in the history of nanoscience was first of all delivered by Feynman that "*There is a plenty of rooms at the bottom*". Now-a-days nannocrystalline materials are in focus to modern scientific research due to their eventual applications. The properties of materials change as their size approaches the nanoscale because surface to volume ratio of the atoms becomes significant.

During the last few decades, ferrites have been studied extensively because of their many technological applications [1-2]. On the basis of magnetic behaviour the ferrites are classified into two broad categories, soft ferrites and hard ferrites. Soft ferrites possesses low coercive field and are easy to magnetize and demagnetize while hard ferrites have large coercive field due to which they are used for permanent magnets. Ferrites, according to the crystal structure and magnetic ordering, can be classified into four categories namely spinel, garnet, magnetoplumbite and orthoferrites. The spinel ferrites are named after the naturally occurring mineral spinel having the chemical formula $MgAl_3O_4$. The general chemical formula of spinel ferrites is (M^{2+}) $[Fe_2{}^{3+}]$ O_4, where M^{2+} represents divalent metal ions such as Zn^{2+}, Co^{2+}, Mn^{2+}, Ni^{2+}, Mg^{2+} etc. or a suitable combination of divalent ions. Soft spinel ferrite materials are widely used in inductors, transformers, antenna rods, loading coils and deflection yokes etc. Spinel nanoferrites are also known to have amazing magnetic properties therefore are also suitable for variety of magnetic applications such as high density magnetic storage, sensors, magnetically guided drug delivery etc. The very interesting factor which is mainly responsible for the modification of the structural, electrical and magnetic properties is the redistribution of the cations over the tetrahedral and octahedral sites. Mg–Mn ferrites are recognized materials for technological applications due to

their high magnetic permeability and low core losses . It is well known fact that the dielectric properties of ferrites are strongly depend on frequency. As the quality of ferrite powder has strong influence on the performance of the final device, hence, the study of dielectric properties at different frequencies will give valuable information about the dielectric relaxation phenomenon [3-9].

Literature Review:

As the general formula of spinel ferrite is MFe_2O_4 so the researchers have so many choice to synthesize different types of ferrites like Ni-Zn, Mn-Zn, Ni ferrite, Mn ferrite, Mg ferrite and Cobalt ferrite etc. K. M. Batto et al [10] have investigated the magnetic and Mossbauer properties of copper substituted cobalt ferrite nanoparticles. R. H. Kadam et al. [11] have synthesized the Gd^{3+} substituted Mn-Cr nanoferrites via sol-gel auto combustion technique and then investigated the structural and magnetic properties. Mg-Mn ferrites are one of the class of spinel ferrites which have their utility in many technological applications. In view of same we have focused our self to study the doped Mg-Mn nanoferrites. In past several researchers have studied the substituted Mg-Mn ferrites [12]. M. Singh et al. [13] have investigated the irradiation effects on the structural, dielectric and permeability properties of In^{3+} substituted Mg-Mn ferrites. S. Ghosh et al. [14] have carried out the positron annihilation and Mössbauer studies of $MgMn_{0.1}Fe_{1.9-x}In_xO_4$ ferrites in bulk and nano form. B. S. Chauhan et al. [15] have reported the magnetic study of citrate precursor processed substituted Mg-Mn ferrites. A. Lakshman et al. [16] have synthesized the substituted Mg-Mn ferrites and reported the electric, dielectric and magnetic properties. S. K. Sharma et al. [17] have synthesized the Mg-Mn nanoparticles via solid state reaction technique and investigated the irradiation effects on the magnetic properties. S. Kumar et al. [18] have studies the effects Ti^{4+} substitution on the electrical and magnetic properties of Mg- Mn ferrites. G. Kumar et al. [19] have studied the temperature dependent electrical properties of Gd^{3+} substituted Mg-Mn nanoferrites. N. Lwin et al. [20] have investigated the effect of thulium ion substitution on the structural and electromagnetic properties of Mg–Mn ferrites. N. Lwin et al. [21] have investigated the physical and electromagnetic properties of Gd^{3+} substituted Mg-Mn nanoferrites.

Research Gap Identification:

In fact many researchers have studied the doped Mg-Mn ferrites in bulk and nano form but no literature is available on the investigation of Ag^{+} and Nd^{3+} substituted Mg-Mn nanoferrites synthesized via solution combustion technique. Therefore, in the present work we have planned to study the effects of Ag^{+} and Nd^{3+} doping on the structural, electrical, optical and magnetic properties of Mg-Mn nanoferrites.

Objectives:

There is enormous scope to explore the Mg-Mn nanoferrites. The main objectives of this study are:

1. Synthesis of Ag^{+} and Nd^{3+} doped Mg-Mn nanoferrites.

2. Structural & morphological study of Ag^{+} and Nd^{3+} doped Mg-Mn nanoferrites.

3. Electric and dielectric study of Ag^{+} and Nd^{3+} doped Mg-Mn nanoferrites.

4. UV spectroscopic and FTIR study of Ag^{+} and Nd^{3+} doped Mg-Mn nanoferrites.

5. Magnetic and Mössbauer study of Ag^{+} and Nd^{3+} doped Mg-Mn nanoferrites.

Proposed Methodology:

The steps to be taken during the research work are given below:

1. **Synthesis of Ag^{+} and Nd^{3+} doped Mg-Mn nanoferrites:** In a stoichiometric ratio ferric nitrate, silver nitrate, magnesium nitrate, manganese nitrate and glycine will be mixed in 80 ml distilled water to obtain the precursor solutions. The obtained precursor solutions will be heated at optimized temperature with constant stirring. The obtained powders will be pre-sintered at optimized temperature so as to obtain the composites.

   Pre-sintered powders will be hydraulically pressed so as to obtain the pellets. Prepared pellets will be sintered at optimized temperature and will be subsequently cooled to room temperature. Pellets will be coated with silver paste to make electric contact for electrical measurements and torroids will be wound with copper wire. The above stated procedure will also be opted for the Nd^{3+} doped Mg-Mn ferrite series.
2. **Structural and morphological study:** The structural study of the synthesized samples will be carried out by the X-ray diffraction study which will be made by Cu-K_{α} radiation of wavelength λ=1.54 Å. The morphology of the synthesized samples will be carried out by scanning electron micrographs.

3. **Electric and dielectric study**: The dc resistivity will be studied as a function of doping and temperature. The dielectric constant and dielectric loss tangent will be studied as a function of frequency and doping.

4. **UV spectroscopic and FTIR study**: The UV spectroscopic study shall be carried out to find the band gap and FTIR study shall be carried out to investigate the effect of doping on metal oxygen bonds.

5. **Magnetic and Mössbauer study**: The magnetic hysteresis measurements of the synthesized samples will be carried out at room temperature. In order to study the complete magnetic behavior Mössbauer spectroscopic analysis will be carried out.

Thesis Outline:

Thesis will comprise five chapters as:

1. **Chapter 1** (Introduction): This chapter includes the introduction of ferrites & types of ferrites, literature review, reasons for the doping of Ag^{+} and Nd^{3+} in Mg-Mn nanoferrites, magnetism and electrical related theories etc.
2. **Chapter 2** (Experimental and Characterization Techniques): It includes the details of the method and techniques which are followed during research work for synthesis and characterization.
3. **Chapter 3** (Results and Discussion): Deals with results analyzed for structural, electrical, dielectric and magnetic properties.
4. **Chapter 4** (Conclusions and Suggestions for Future Work): This chapter will Comprises summary of entire study according to objectives along with conclusions. The scope of further research on the basis of recommendations will also be illustrated in this chapter.

Research Plan Schedule:

Research Activity	Progress in Months											
	3	6	9	12	15	18	21	24	27	30	33	36
Course work, extensive literature survey or design of work	Jan 2015 to Jan 2016											
Research gap identification and development of methodology		Sep 2015 to March 2016										
Preparation and characterization of the samples and manuscripts preparation for publications						Jan 2016 to April 2017						
Thesis writing and thesis submission									May 2017 to Dec 2017			

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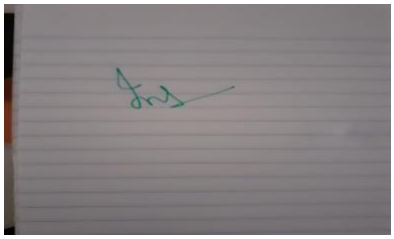

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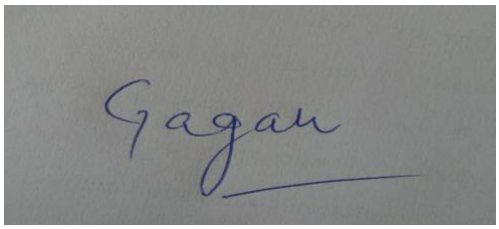

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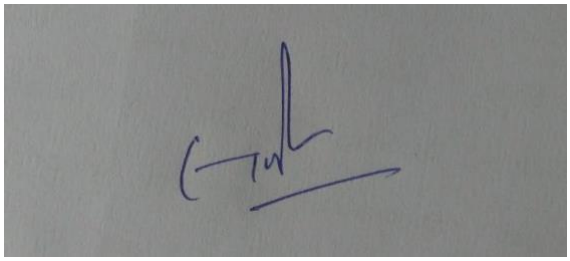

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